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Male *Bembix furcata* Erichson (Hymenoptera: Sphecidae) Behaviour on a Hilltop in Queensland

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Abstract.—Territorial behaviour of male *Bembix furcata* was observed on a hilltop in southeast Queensland. Removal of territorial males resulted in rapid replacement by males which tended to be smaller. The location of the males differed from previous observations and suggested a landmark-based mating system.

The sphecid wasp *Bembix furcata* Erichson occurs in cool, moist habitats in southern Australia, and nests have been found only in alluvial soils (Evans and Matthews, 1973). Evans and Matthews (1973) observed males flying in repeated or irregular patterns in the nesting area and "obtained the impression" that males were territorial.

In spring 1987 we observed the behaviour of marked male *B. furcata* on a hilltop in southeast Queensland. We conducted removal experiments to 1) investigate the relationship between the sizes of original territory holders and their replacements and 2) estimate the number of individuals in the local population.

The study took place on Mt. Marlay (elevation 991 m) at Stanthorpe, Queensland. Male wasps were observed from 3 to 9 November 1986. In 1987, wasps first appeared in mid-October and were present through to our departure on 3 December. Wasps were absent on a warm, clear day on 15 January 1988. The apparent adult season of October to at least December in southern Queensland compares to the period noted by Evans and Matthews (1973) of December to March for this species in the Australian Capital Territory.

Seven males were netted and marked on the thorax with unique combinations of nontoxic, water-based paint. Maximum head width (to the nearest 0.1 mm) was measured with callipers under a dissecting microscope. Wasps were released immediately at the site of capture or held in a shaded net in the case of removal experiments. Five of the marked males and four unmarked males were caught and killed on 4 November. Four more males were caught and killed when we returned on 3 December. Using an ocular micrometer, the following measurements were taken for all specimens: head widths (confirmed for the marked wasps), wing lengths (from the apex of the humeral plate to the apex of the wing), and thoracic lengths (from anterior margin of the scutum to the posterior margin of the scutellum).

Head widths ranged from 5.0 to 5.6 mm ($\bar{x}$ = 5.2, SE = 0.04, n = 13), wing lengths from 12.6 to 14.3 mm ($\bar{x}$ = 13.2, SE = 0.16, n = 13), and thoracic lengths from 4.5 to 5.5 mm ($\bar{x}$ = 5.1, SE = 0.06, n = 13). Each measurement was

significantly correlated with the other two (Pearson correlations: head width versus wing length, $r = 0.90$; head width versus thoracic length, $r = 0.74$; wing length versus thoracic length, $r = 0.66$; $n = 13$ and $P < 0.01$ for each case).

As of 31 October 1987, males were consistently present in five sites on the hilltop. All five sites were within 30 m of the dome-shaped summit. Searches of the remainder of the hilltop and bushland at the base of the hill revealed no other sites with wasps. Three contiguous sites were regularly occupied along a dirt road leading to the summit. The other two sites were clearings composed of granite boulders and grass within otherwise wooded areas. These clearings were approximately 5 m^2. All sites were in full sun for most of the portion of the day that wasps were active on the hill.

Male *B. furcata* behaviour in these sites consisted of almost constant flight with frequent darting movements towards other nearby insects. The pattern of flight was apparently dependent, in part, on the physical characteristics of the site being used. In the "road" territories an individual male flew over the same path continuously, perching infrequently and briefly. Wasps flew 10–20 cm above the ground, precisely following one of the two tyre tracks for 10–15 m in one direction, then turning and retracing the same path. In the "clearing" sites, wasps exhibited a more compact flight pattern within the relatively confined space. In all cases intruding males were immediately chased and only one male returned to continue patrolling.

Males departed if the sun was obscured for long periods after their arrival. No males appeared on overcast days. Initial arrival varied from 0830 hr to 0946 hr (EST) over the 5 days that we recorded times. The latest that a male remained in his territory was 1403 hr. *B. furcata* and other *Bembix* spp. males are known to dig sleeping burrows in areas where they are active during the day (Evans and Matthews, 1973). Burrows are dug in the afternoon and may be reused on consecutive nights. We saw no evidence of the construction or use of sleeping burrows by these males.

Six of the seven marked males reappeared on all days after the day they were marked. With the exception of one male which moved between all of the sites, the remaining marked males had regular territories to which they returned each day, either as the dominant resident or as a challenger for the site.

We removed resident males on 16 occasions (Table 1). Replacements by other males occurred in 12 cases and within a mean time of 7.8 $\pm$ 6.3 min (SD). The four cases in which replacements did not occur were on the final day when we captured and held all residents and replacements (a total of 9 wasps). The last replacement on that day was well before the wasps normally departed. This suggests that the territorial males were drawn from a pool of nine individuals on the hill that day. In eight out of the 11 replacements in which the sizes of the males were known, the replacing male was smaller than the original male (Table 1).

Thus, we found some evidence suggesting that size influences territory ownership, but it was less than conclusive. In provisioning wasp species for which there are reports of strong correlations between size and territory ownership (e.g., Alcock, 1979; O'Neill, 1983a, 1983b), there was greater variation in the sizes of males involved compared to what we observed. Clearcut advantages of one male over another might not be expected when size differences are slight.

When we returned on 3 December the same sites were occupied. We captured

Table 1. Sizes of males and time between removal and replacement of territorial males of the wasp *Bembix furcata.*

			1 November		2 November		3 November		4 November	
Site	Male	Head width (mm)	Arrived	Caught	Arrived	Caught	Arrived	Caught	Arrived	Caught
1	A	5.6	0946	0952	0927	1238	0830	0931	—	—
1	B	5.3	1006	1010	1240	—	0938	1012	1039	1140
1	C	5.1	1015	1300					1023	1036
1	D	5.2	1319	—			1021	—	0914	1022
2	E	5.2					?	1323	0921	1128
2	F	not captured					1342	—		
3	G	5.2							0932	0943
3	H	5.2							0947	1028
3	I	5.3							1031	1032
3	J	5.0							1047	1059
4	K	5.0							?	1108

four males between 1200 hr and 1300 hr, after which no more males appeared. Three of these males were larger than all but one of the 10 males measured a month earlier.

We saw no evidence of nesting activity or adult emergence within or near the hilltop sites. Thus, the described male behaviour, although similar to that observed by Evans and Matthews (1973) in a nesting area, was occurring in a totally different location. We cannot rule out the possibility that females initiated and completed nesting in these areas during the time that we were absent (4 December–14 January). However, because that would represent a very different nesting habitat and substantially shorter nesting period than previously documented for *B. furcata* (Evans and Matthews, 1973), we feel it is unlikely.

It is common among insect species for individual males to monopolize access to females by defending areas where females are aggregated (Thornhill and Alcock, 1983). Such "female defense polygyny" is widespread within the solitary wasps because of the tendency for females to be clumped at nesting and emergence sites or food plants (e.g., Alcock, 1976; Evans and Matthews, 1973; Gwynne, 1980). For the reasons given above, we regard it as highly unlikely that the males we observed were within, or on the periphery of, nesting areas. Yet, nothing other than mate acquisition can satisfactorily account for the males' territorial behaviour. Thus, we interpret this as a probable landmark-based mating system in which males patrol hilltop territories in an attempt to intercept females coming to the landmark to locate a mate. We did not see females or matings during the period that we observed the wasps; however, this is in concordance with many landmark-based systems in which low frequency of observed matings is an inherent property (Thornhill and Alcock, 1983). It could be postulated that these males have been excluded by other males from the nesting or emergence area and are exercising the subordinate option of defending territories elsewhere and waiting for unmated females at a landmark. However, we cannot envisage how females could gain by avoiding males at the emergence site and then flying to a hilltop to mate, unless this option avoids deleterious levels of inbreeding (see Matthes-Sears and Alcock, 1986) or lowers the risk of injury from competing males (Evans et al., 1986).

With one possible exception (Matthes-Sears and Alcock, 1986), the instances of landmark-based mating systems in wasps occur in species that exhibit dispersed and unpredictably located females, i.e., species in which neither females nor resources they require appear to be economically defendable (Alcock, 1979, 1985; Evans and O'Neill, 1985, and references therein). Thus it would be important to determine whether the wasps we observed came from a local population that does not have spatially aggregated nests.

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Scientific Note

Semidalis arnaudi Meinander, 1972 (*Planipennia, Coniopterygidae*), a New "Dustywing" Species to the Fauna of the United States

The coniopterygids or "Dustywings" are the smallest of the order *Planipennia* ("Superord." Neuropteroidea). They were earlier considered rare, but modern investigations have shown that they have been overlooked (Meinander, 1972, Acta Zool. Fennica, 136:1).

The last revision of the family was made by Meinander (1972) who described many new species. *Semidalis arnaudi* Meinander, 1972, was described from the Sonora province, North West Mexico. Meinander in two following papers (1974, Entomol. Scand., 5:217; 1975, Notul. Entomol., 55:28) described additionally new species and gave new records of Coniopterygidae from Western North America. *S. arnaudi* was mentioned from one locality in Mexico, viz. Isla Cerralvo in the Baja California Sur (Meinander, 1974).

I collected 3 ♂ and 1 ♀ of *Semidalis arnaudi* during a week's stay in Tucson, Arizona in October 1987. The specimens were netted from low herbage in a garden on two different dates: 1 ♂ and 1 ♀ on 11 October, 2 ♂ on 16 October. The garden is situated in a suburb bordering to the South West rim of the Santa Catalina mountains.

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